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The Effect of Ascending-Price Electric Power Tariffs on Consumption of Electricity

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THE EFFECT OF ASCENDING-PRICE ELECTRIC POWER TARIFFS ON CONSUMPTION OF ELECTRICITY

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This thesis submitted by James M. Dalglish in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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ABSTRACT

This thesis represents an attempt to evaluate the effects which would result from the inversion of electric power tariff structures. Tariff relationships are presently based upon both the cost and value of service. The unit price for electricity presently decreases as monthly consumption increases.

Electric utilities are required to: (1) supply all reasonable demands for service by those who can pay for it, (2) provide service adequate to the needs of customers, (3) price such service at reasonable rates and without unjust discrimination.

The demand for electricity is a segment of the demand for energy of all types. Growth in the demand for energy has been closely related to economic growth in general. Total annual sales of electricity have been roughly doubling every ten years since the 1920's.

Unit prices of electricity experienced a declining trend until 1970. In the late 1960's, electric utilities began asking for general rate increases, which caused the reversal of this trend. Proponents of inverted rates assume that the demand for electricity is sufficiently elastic to respond noticeably to the price charged per kilowatt-hour. Factors which affect the elasticity of any product include: (1) the product's cost in relation to the total family

or business budget; (2) the availability of substitutes; (3) the degree of necessity attached to the product; (4) the extent to which the customer realizes how much he is paying for a given product or service; (5) the length of time a given price has been in effect.

The basic conclusion drawn from this study is that the demand for electricity is not sufficiently elastic with respect to price to respond appreciably when an inverted rate is applied. The reasons for this conclusion are as follows:

(1) The relative amount spent on electricity by both residential and industrial users is small.

(2) It is possible to use substitute forms of energy for some uses of electricity. These substitute forms of energy are in shorter supply than is electricity, however, and the price of substitutes is expected to increase faster than is the price of electricity.

(3) Consumers of electricity do not think in terms of cost per kilowatt-hour but in terms of dollars spent on electricity per month. They have little knowledge about the unit or monthly operating cost of various uses of electricity.

Under the circumstances listed above, the inversion of electric tariffs appears to have little effect on the consumption of electricity.

CHAPTER I

PURPOSE AND ORGANIZATION

Introduction

The purpose of this thesis is to describe and analyze the possible effects which would result from the inversion of electric power rate structures. Inversion is the process of reversing tariff schedules of utility firms so that cheaper unit-rates apply to initial power usage and more expensive unit-rates to subsequent use. The present practice of utility companies is to set prices high enough to cover customer, fixed, and variable costs incurred in the delivery of electricity to each customer. Because of relatively constant customer costs, the companies have sought to recover those costs by charging relatively high rates in the initial part of the tariff, while subsequently lowering the unit-rates for each following block of service.

Objective of Study

The inversion of power rate structures has been advocated by some ecologists, consumerists, and politicians for several reasons. First, the proponents of inversion believe that the increasing use of electric power represents a threat to our environment and natural resources. They feel that a large segment of this increasing usage results from the frivolous use of "luxury items" which are not necessary to an adequate quality of life and that those who consume more power for such use should pay proportionately more for it than those who conserve on power.

Second, they feel that such a concept would be a good vehicle for social reforms. Proponents feel that the poor should not be forced to pay a higher unit rate than the affluent who use more electricity and therefore speed resource bankruptcy. Also expressed has been the idea that higher end-use rates would discourage industries from using many labor saving machines and replace them with human labor, thereby reducing unemployment.

With the general public becoming increasingly concerned about our environment and the social responsibilities of business, this topic will continue to be explored until a consensus of its effects is gained by regulators, suppliers, and interested consumers. This study is an effort to contribute some understanding of the factors which must be considered before such a practice is initiated and to predict what the outcome of rate inversion would be.

Limitations of Study

Electric rates are almost always regulated and are therefore rather stable. It is difficult, consequently, to observe any major changes in power use which can be directly attributed to rate changes. This precludes the determination of a direct quantitative measure of the relationship between price and consumption. General, non-quantitative relationships can be observed which, during the course of the study, will be used to predict future price-demand results.

Organization of Study

To facilitate an evaluation of the specific results of rate inversion, those characteristics of public utility marketing which make it somewhat different from the marketing of other goods and services will be discussed. Present utility pricing policies will be explained, and tariff structures presently in use will be illustrated.

The next chapter contains an analysis of the demand for electricity. Energy consumption trends are noted, as are the effects of competition on the demand for electricity. Factors affecting the price and income elasticity of demand are also discussed.

Contained in the following chapter are examples of attempts at electric demand manipulation through changes in the pricing structures of utility tariffs. The section also contains an illustration of the possible effects of arbitrary tariff step changes on the monthly billing of average large users of electricity in New York City.

The final chapter of the study contains a summary and the conclusions which have been reached.

CHAPTER II

CHARACTERISTICS OF ELECTRIC UTILITY MARKETING

Public Utility Status

The public utility is unlike other stock corporations. It operates as a monopoly with government approval. Regulation by governmental bodies has been accepted as a substitute for regulation through the actions of competition in the market. This governmental regulation achieves the results of competition by monitoring the rates, profits, and service quality of the utility.[1]

Two reasons have been advanced for allowing and encouraging monopoly status. The first reason is that public utilities supply services indispensible to modern living. They are "affected with the public interest." The second is that public utilities are natural monopolies. Because of their technical characteristics, they cannot be operated with economy or efficiency unless they monopolize the market.[2] Direct competition and duplication of facilities will almost certainly lead to bankruptcy or merger.[3] Even if several firms

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[1]Paul J. Garfield and Wallace F. Lovejoy, Public Utility Economics (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964), p. 1.

[2]James C. Bonbright, Principles of Public Utility Rates (New York: Columbia University Press, 1961), p. 11.

[3]Charles F. Phillips, Jr., The Economics of Regulation (Homewood, Ill.: Richard D. Irwin, Inc., 1965), p. 22.

were able to exist under these conditions, they would waste resources.[4] Reinforcing the natural monopoly concept is the fact that electric utilities have historically achieved decreasing average unit costs as output increased. The decreasing average unit cost situation is caused by the following five factors:

(1) The heavy investment in fixed assets which is required of electric utilities.

(2) The large constant costs which are a function of plant size and not of production quantity.

(3) The large utility is more able to take advantage of larger and more efficient units of plant made possible by technological advancement.

(4) The more diversified demand which usually results if an entire market, rather than a partial market, can be served.

(5) The relatively large firm can buy in larger quantities, thus decreasing purchasing and other related costs.[5]

<u>Rights and Duties of Public Utilities</u>

A public utility's rights and duties have been determined through a long series of laws and court decisions.[6] The rights include:

(1) The power to charge a reasonable rate for its service which will allow it to collect revenues sufficient to cover all operating

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[4]Bonbright, <u>Principles of Public Utility Rates</u>, p. 11.

[5]Garfield and Lovejoy, <u>Public Utility Economics</u>, pp. 17-18.

[6]<u>Ibid.</u>, pp. 12-13.

expenses, taxes, depreciation, a return on its net valuation including debt interest, dividends on capital stock, and a contribution to earned surplus.

(2) The granting by public authority of a franchise to serve a specific area free from competition from another seller of the same service..

(3) The right of eminent domain for the limited purpose of acquiring private property or the rights to its use as required to serve the public.

(4) The right to operate under reasonable rules and regulations.

The duties include:

(1) The requirement to supply all reasonable demands for service by those who can pay for it.

(2) The obligation to provide service adequate to the needs of its customers.

(3) The pricing of service at reasonable rates and without unjust discrimination.

(4) The prohibition of changing utility service or expansion into a new market without prior finding by a regulatory agency that such is in the public interest.

(5) The exercise of care to protect the safety of the public.

(6) The securing of approval from public authority before termination of service or abandonment of market.

Regulatory Development and Scope

History of Regulation

Social control and the regulation of private enterprise can be traced back to very early times. There is evidence that forms of regulation existed in Greek City States and the Roman Empire.[7] Regulation expanded gradually through the "just price" standard of St. Augustine and "national economy" viewpoint of mercantilism in Sixteenth Century France.[8]

The beginning of public regulation of utilities in the United States was the Munn v. Illinois[9] case which advanced the right of the state to regulate those firms "affected with a public interest." Thus began the "legislative phase" of utility regulation. Prior to that time, regulation had been attempted through lawsuits. This judicial regulation had proven to be unsatisfactory because of the cost and delay inherent in such proceedings.[10]

The Hope Natural Gas[11] case marked the beginning of the "administrative phase" of regulation by putting forth the "end result doctrine." The Supreme Court ruled in this case that it would interfere with the decisions of regulatory

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[7]Martin G. Glaeser, Outlines of Public Utility Economics (New York: The Macmillan Company, 1929), pp. 156-58.

[8]Ibid., pp. 158-60.

[9]Munn v. Illinois, 94 U.S. 113 (1877).

[10]Garfield and Lovejoy, Public Utility Economics, p. 27.

[11]Federal Power Commission v. Hope Natural Gas Co., 320 U.S. 591 (1944).

agencies only in the case of obvious injustice. This ruling was a refinement of the notion of "zone of reasonableness" theory of return on investment which had been spelled out in a Wisconsin telephone rate case.[12] The lower limit of such a zone is the point at which confiscation of the property of a private company would result. The upper limit of the zone is that point at which buyers would begin to be exploited and pricing practices lead to monopoly profits.

By 1970, regulation of electric rates by local franchise had been replaced by state commission regulation in all but three states. Some practices of interstate gas and electric utilities are also reviewed by the Federal Power Commission.

Rate Regulation Concepts

Utility tariffs, or "rates" as they are known in the electric power industry, must yield required revenues while meeting the "just and reasonable" requirement. Rate relationships are therefore based on both the cost and value of the service.[13] The cost of service includes:[14]

(1) Operating expenses.

(2) Depreciation expenses.

(3) Taxes.

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[12] Wisconsin Telephone Co. v. PSCW, 323 Wis. 274, 329 (1939).

[13] Phillips, The Economics of Regulation, p. 305.

[14] Garfield and Lovejoy, Public Utility Economics, p. 94.

(4) A reasonable return on the net valuation as adjudged in the Bluefield Water Works[15] and Smyth v. Ames[16] cases.

The Public Service Commissions cannot guarantee a specific rate of return but can determine the maximum allowable return.

Although the authors of texts on public utility economics generally concede the importance of cost, they also contend that the value of service principle should be taken into account.[17] The value of service principle applies to the relative price elasticities of various classes and uses of a service. Rate discrimination between different classes of customers has been allowed as the means by which a utility can earn its revenue requirement while the constructive utilization of a service is promoted.[18] The Supreme Court has stated that:

(1) A rate may be made for individual classes of service.

(2) All classes of service need not have uniform rates.

(3) The same percentage of profit need not be gathered from each kind of service.

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[15]Bluefield Water Works and Improvement Co. v. Pub. Serv. Comm. of W. Va., 262 U.S. 679, 692-93 (1923).

[16]Smyth v. Ames, 169 U.S. 466, 547 (1898).

[17]Bonbright, Principles of Public Utility Rates, p. 82.

[18]Northern Pacific Railway Co. v. North Dakota, 236 U.S. 585, 598-599 (1915).

(4) The value of service will be among those factors considered in setting rates.[19]

The most prominent illustrations of value of service principles in rates are found in railroad freight tariffs. The same principle guides electric and gas rates.[20]

Distribution and Pricing Characteristics

Physical Characteristics of Service

A basic physical characteristic of electricity is that it is impossible to store it in significant quantities.[21] The demand for the service fluctuates sharply over time and must be met instantaneously. The periodic fluctuations follow daily, weekly, and seasonal patterns throughout the year. The capacity of generating stations, transmission lines, transformers, and other capital equipment must therefore be based on the highest demand expected for that particular equipment. In addition, the utility must provide sufficient reserve generation capacity in order to assure continuity of service in the event of a breakdown.

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[19] Ibid.

[20] Bonbright, Principles of Public Utility Rates, p. 84.

[21] H. S. Houthakker, "Electricity Tariffs in Theory and Practice," The Economic Journal, LXI, No. 241 (March, 1951), 2.

Public Utility Cost Categories

As previously mentioned, electric utility rates are based on cost and value. The cost of providing electric service can be divided into four categories as follows:

(1) Energy Costs--which change as the amount of energy generated changes. These include such things as fuel, fuel handling, some power plant operation and maintenance charges, and energy lost in transmission.

(2) Demand or Capacity Costs--which depend on the maximum demand anticipated. Included are most plant-related costs such as return on rate base, principal taxes, depreciation accrual, and most operation and maintenance expenses.

(3) Customer Costs--a function of the number and kinds of customers. These include meter reading, accounting, billing, and some capital equipment.

(4) Residual Costs--which are those which do not belong to any of the above categories. These are a small portion of total cost and include costs associated with management.

Electric tariffs are designed so that the initial step attempts to recover the customer costs. Demand and residual costs are normally recovered in the first few steps. Energy costs are recovered last. This system of cost recovery has led to the prevalence of declining block rates in the United States. If only energy costs were recovered in the first step, a small user would possibly never remunerate the utility for its customer, demand, and residual costs incurred in serving that customer. It may not mean that the customer would use more. He could install several meters, each measuring electricity used by some of his appliances, and thus reduce his electric bill while consuming the same total amount of electricity. If all four categories of costs are recovered in the first step of the rate schedule, that step will have a higher unit cost than the last step, which recovers only energy costs.

Early electric tariffs were in the form of a flat rate, under which the customer was charged a lump sum for a specific time period, such as $5 per month, regardless of the extent of use of the service. Many of these flat rates evolved into "straight line meter rate" schedules which provided service at a constant charge per metered unit such as 6 cents per kilowatt-hour. Both flat and straight line rates are used today under special conditions. Flat rates are employed in cases of non-variable or easily predictable uses such as automatic protective night lights and street lights. Straight line rates are sometimes used with automatic interrupting devices, such as time clocks, which prevent appliances, such as water heaters, from operating during normal daily peak hours. The advantage of both of the above rate schedules is their simplicity.

Most residential and other small volume customers are served from variations of "block meter rate" schedules offering decreasing price per unit of energy for succeeding blocks of consumption. The bill is calculated by accumulating the charges for each successive block or fraction thereof. This type of tariff is illustrated in Table 1.

TABLE 1

BLOCK METER-RATE SCHEDULE

Consumption Quantities	Unit Rate
First 10 kWh	$1.00
Next 40 kWh	4.5 cents per kWh
Next 50 kWh	4.0 cents per kWh
Next 100 kWh	3.0 cents per kWh
Excess kWh	2.0 cents per kWh

Minimum charge--$1.00 per month

A seldom-used predecessor of this type of tariff was the "step meter rate" schedule illustrated in Table 2.

TABLE 2

STEP METER-RATE SCHEDULE

Consumption Quantities	Unit Rate
If 25 kWh per month or less are used	6 cents per kWh (for all kWh used)
If from 26 to 100 kWh per month are used	5 cents per kWh (for all kWh used)
If from 101 to 200 kWh per month are used	4 cents per kWh (for all kWh used)
If more than 200 kWh per month are used	3 cents per kWh (for all kWh used)

Under this system, one price was charged for each unit of energy for the entire amount consumed. The customer's bill was determined by the price assigned to the particular block in which the total consumption happened to fall. Because the price decreased with each successive block, it was sometimes possible for a customer to reduce his over-all bill by wasting service until consumption came within the next lower-priced block.

A widely used tariff for larger commercial and industrial users is the "Hopkinson Demand Rate" named after its founder. It is a two-part tariff consisting of separate charges for maximum demand and for energy consumption. The total bill is the sum of the two charges. Demand, for billing purposes, is often measured over a fifteen or thirty minute period and is either recorded graphically or indicated by a pointer. The pointer does not return to zero after each reading but remains at the point of peak demand until it is pushed higher by a greater usage over a like period. This type of rate schedule is illustrated in Table 3.

Another tariff normally applied to commercial and industrial customers is the "Wright Demand Rate," also named after its founder. It differs from the Hopkinson Rate in that separate demand and energy charges are not made. The Wright Demand Rate combines the two in a blocked energy charge based on the number of hours that the maximum demand is used each month, as calculated by dividing the total kilowatt-hours by the maximum demand. Succeeding blocks have decreasing rates and increasing size as shown in Table 4.

TABLE 3

HOPKINSON DEMAND RATE

Demand Charge

Unit Rate	Consumption Quantities
$2.00 per kVa	First 10 kVa of demand
$1.75 per kVa	Next 40 kVa of demand
$1.50 per kVa	Next 50 kVa of demand
$1.20 per kVa	Next 100 kVa of demand
$1.00 per kVa	Excess kVa

Energy Charge

2.50 cents per kWh	First 1,000 kWh
2.30 cents per kWh	Next 2,000 kWh
2.00 cents per kWh	Next 5,000 kWh
1.70 cents per kWh	Next 10,000 kWh
1.50 cents per kWh	Next 20,000 kWh
1.20 cents per kWh	Next 100,000 kWh
0.90 cents per kWh	Excess kWh

Both the Hopkinson and Wright schedules reflect differences in load factor so that if a customer increases his use without increasing his maximum demand proportionally, his load factor will increase and average rate decrease.

The final type of tariff is known as the "Doherty Three-Part Rate" schedule. It is essentially a Hopkinson Rate plus a separate service charge designed to cover the customer cost. It has not been widely used.

TABLE 4

WRIGHT DEMAND RATE

5.0 cents per kWh for the first 50 hours' use of demand per month

4.0 cents per kWh for the next 100 hours' use of demand per month

2.0 cents per kWh for the next 150 hours' use of demand per month

0.9 cents for all energy in excess of 300 hours' use of demand per month

Minimum bill--$1.00 per kW of demand per month

Tariff Structure Evaluations

Bonbright states that consideration should be given to the following criteria when selecting the proper type of tariff for a particular application:

(1) It should have the related attributes of simplicity, understandability, public acceptance, and feasibility of application.

(2) It should be free from controversy regarding proper interpretation.

(3) It should be effective in yielding revenue requirements under the fair return standard.

(4) It should produce year-to-year revenue stability.

(5) It should remain stable, with few unexpected changes seriously adverse to existing customers.

(6) It should fairly apportion total costs of service among customers.

(7) It should avoid discrimination in rate relationships.

(8) It should contain classes and blocks which discourage wasteful use of the service while promoting justified uses.[22]

Tariff Complexity

As evidenced by the previous description of electric rates in this chapter, individual tariffs are complex. Moreover, the goals of these tariffs occasionally conflict. Effective revenue procurement can conflict with fairness. Revenue stability can conflict with understandability and simplicity.

The complexity of the rates is further compounded by the fact that a single utility may offer several block meter rates to residential customers depending on their geographic location, the types of electricity-using devices (heaters, water heaters, etc.) they possess, and whether they require overhead or underground wires to the home. This same utility may offer a choice of block meter rates, Wright Demand Rates, or Hopkinson Demand Rates. The customer, with the assistance of a utility representative, must ultimately decide which rate will be economically best for his application from among those offered. The consumer typically does not think in terms of cents per kilowatt-hour. He thinks in terms of his normal electric bill in dollars per month. If the steps of the rate schedule are rearranged but the monthly bill

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[22]Bonbright, Principles of Public Utility Rates, p. 291.

remains constant, the average electric consumer will probably not notice any change.

Until recently, many utilities have pursued advertising campaigns based upon illustrating the inexpensive nature of their service. Slogans, such as "electricity is penny cheap," have been widely used. Other ads have noted the number of slices of bread which could be toasted or the number of eggs which could be fried for a penny using average residential electric rates. Campaign messages have stressed the point that a consumer's total electric bill might have risen over the years but that the rates have decreased. The increased bill has been attributed to the greater use of more electric appliances.

A 1971 survey for one large upper midwest energy supplier indicated that in response to the question, "Do you feel that the power company that serves you takes advantage of its monopoly by charging unfair prices for electricity?" 23 per cent agreed, 62 per cent disagreed, and 15 per cent of the respondents did not know.[23]

The consumer is frequently unaware how his electric bill breaks down by cost elements such as lighting, refrigeration, hot water, and air conditioning.[24] Illustrating how little the customer knows about his electric

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[23]Barbara M. Rogoff and Guy H. Miles, "NSP Public Attitude Research Survey," North Star Research and Development Institute, Minneapolis, 1971, p. 38. (Mimeographed.)

[24]State of New York, Department of Public Service, Office of Economic Research, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," 1972, p. 16. (Mimeographed.)

billing and use is a special survey conducted for Consolidated Edison Company of New York in 1968, which indicated that little difference existed in the patterns of consumption between tenants who paid their own electric bills and those who had utilities included in their rent.[25]

Some electric utilities have published information pieces indicating normal operating costs per hour, month, or year of individual appliance operation in order to furnish the consumer some operating cost information.

Differential Pricing

Regulatory commissions have prohibited the resale of electric energy from one customer to another to prevent further confusion and the possibility of unregulated profiteering. This prohibition has, however, allowed the distributor to levy charges not exactly proportional to consumption.[26] Consequently, utility firms employ differential pricing systems.

Under a system of differential pricing, relatively homogeneous customer classes are established, and a different rate schedule is applied to each class. All customers within a given class must have the same rate schedule available to them. Common class groups are residential, commercial, industrial, rural or farm, street lighting, and other uses.

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[25]Audits and Survey, Inc., Appliance Ownership and Electricity Awareness, May, 1969; An Evaluation of Specific Factors Influencing Electric Power Usage, June, 1967; as mentioned in State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 16.

[26]Houthakker, "Electricity Tariffs in Theory and Practice," p. 2.

Subgroups are often made, based upon geographic location and/or population density. Normal classification is based on the size or amount of total usage expected and the purpose to which the service is devoted.[27]

The system of differential pricing has been justified by both utility industry and regulatory commission rate specialists on the basis that demand differences, service differences, and cost differences exist between customers and groups of customers. Value differences also exist. Some uses of electric service have better substitutes than others. A gas dryer can substitute for an electric dryer in many cases. There is no good substitute for an electric clothes washer.

The objectives of a differential pricing policy are to:

(1) Earn the revenue authorized by the regulatory commission.

(2) Promote sales to maximize utilization of plant capacity and thereby reduce average unit costs of supplying all service.

(3) Charge more heavily those customers who create peak demands, in order to encourage them to shift to off-peak use.[28]

The second of these objectives is presently being questioned by those fearing ecological damage and resource depletion.

Differential pricing based on value has been condoned by regulatory commissions as indicated in an early natural gas case:

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[27] Garfield and Lovejoy, <u>Public Utility Economics</u>, p. 137.

[28] <u>Ibid</u>., p. 23.

> To justify the separate classification of any utility service there must be something different about that particular service which makes it different from any other service which that utility furnishes to the public.
>
> The essential fact which makes the respondents' space heating service different . . . , and thus justifies separate classification . . . , is the simple fact that gas used for space heating is not worth as much as gas which is used for other purposes for which respondents' other consumers make of the gas.
>
> The difference is value between gas for space heating and the same gas for other uses furnishes the logical basis for the separate classification for respondents'. space heating services because of the fundamental principle of rate making that reasonable utility rates cannot result in charges for any utility service which are more than such service is worth to the customer. This principle was established in "Smyth v. Ames" (1898) . . . .[29]

The possible ranges of the rate differential is illustrated by the Wisconsin Public Service Commission, which spelled out the range within which a gas rate for space heating purpose should fall:

> It is clear that the rates . . . permit a recovery not only of the incremental expense incident to respondents' space heating services, but also some portion of the remainder of the total operating and other expenses comprising the total costs of furnishing respondents' services in their entirety. We think that this is not only proper, but that rates for such . . . service should be designed to recover as much of such remainder of costs as it is possible within the limitation of the value of such services . . . .
>
> Just as the incremental cost of the space heating services of respondents serves as a criterion (although not the measure) of the minimum level of rates that could lawfully be prescribed for such services, so their the space heating services value is both a criterion and a measure of the maximum level of rates that can reasonably be prescribed for the same services . . . .[30]

The New York Public Service Commission has also stated:

> . . . In making rates, consideration must be given to both the cost of service and its value . . . . As a measure of rates, value of service

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[29] Re Milwaukee Gas Light Co., <u>et al</u>., 51 PUR (NS) 299, 306, 307 (1943).

[30] Re Milwaukee Gas Light Co., <u>et al</u>., 51 PUR (NS) 299, 310 (1943).

> alone is an elusive standard and not satisfactory as a yardstick . . . . Neither is cost of service a proper measure standing alone . . . .[31]

As a result of these differential rates, average price per kilowatt-hour drops as consumption of electricity increases, thus benefiting the small users of residential service with the more highly elastic demands.[32]

The unit cost of serving a smaller customer is normally higher than that of a large user.[33] It has been reported by one utility that essentially the same facilities were used to serve an electric heat customer who used 25,000 kilowatt-hours per year as the average customer who used only 5,000.[34]

In addition to cost differences, small residential customers as a class place a higher value on their service than do large industrial customers.[35] Large industrial customers place a ceiling on the value of electricity based on their estimated costs of self generation and internal distributions. This option is rather remote in the case of residential customers.

Alternative Sources of Electricity

In addition to the self-generation alternative, the possibility also exists that a large firm could relocate in a different part of the country in order to

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[31] Re New York Telephone Co., PUR 1930C, 325, 367.

[32] John Pike, "Residential Electric Rates and Reguations," The Quarterly Review of Economics and Business, VII, No. 2 (Summer, 1967), 47.

[33] Ibid.

[34] John H. K. Shannahan, "Should Electric Utilities Stop Marketing?" Public Utilities Fortnightly, LXXXVII, No. 8 (April 15, 1971), 16.

[35] Garfield and Lovejoy, Public Utilities Economics, p. 150.

escape high power costs. This alternative seems unlikely unless power costs are a major cost of doing business. Most plant locations are based more upon such factors as nearness to market, availability of raw materials, and availability and cost of labor. Small users are tied down more than are large users, however.

Geographic Distinctions

The location of a consumer's residence can have a great bearing on his ownership of electric appliances and therefore on his use of electricity. An analysis of the 1970 Census of Housing indicates that the per capita ownership of air conditioners in Arizona and Florida is much greater than in North Dakota.

Another location factor is the urban-rural lifestyle difference. Food freezers and laundry equipment may not be a necessity in a large city where supermarkets and laundromats or apartment coin-operated laundries exist. These facilities are not convenient to rural housewives, who must do their laundry at home. With our modern lifestyle, the food is kept frozen somewhere, and the clothes are washed somewhere. This is locational replacement and not an abstention from washing clothes or eating convenience foods. In North Dakota, customers of stockholder-owned utilities consisting almost exclusively of town dwellers average 530 kilowatt-hours of use per month. Customers of Rural Electric Cooperatives, consisting almost exclusively of rural-area dwellers, average 805 kilowatt-hours of use per month.[36]

Summary

This chapter related the unique characteristics of public utilities and the manner in which those characteristics affect utility marketing. Utilities have been allowed monopoly status because they provide an indispensible service and operate with greater efficiency as monopolies. The rights and duties of public utilities, determined through a long series of laws and court decisions, were listed. A capsule history of the regulation by governmental bodies which substitutes for competition in the case of public utilities was presented.

Utility tariffs, or "rates," are required by law to be "just and reasonable." Such tariffs are based upon both the cost and value of service. Criteria normally used to evaluate the fairness and effectiveness of individual tariffs were listed. Because tariffs are complex, and all service normally passes through one meter, customers are unaware how their bill breaks down by such cost elements as lighting, air conditioning, refrigeration, and other uses. The customer views his electricity purchases in terms of dollars per month per metered use.

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[36]State of North Dakota, Public Service Commission, "Comparison of Rate Schedules for Electric Service to Small Town North Dakota Residential Customers," 1973, p. 2. (Mimeographed.)

Utilities employ systems of differential pricing. These systems have been justified on the basis that demand differences, service differences, and cost differences exist between customers and groups of customers.

CHAPTER III

CONSUMPTION AND COMPETITION: AN ANALYSIS OF THE DEMAND FOR ELECTRICITY

Energy Consumption Trends

The demand for electricity is a segment of the demand for energy of all types. Growth in energy demand has been closely related to economic growth in general, playing a major role in contributing to the material well-being of mankind.[1] During the period from 1880-1920, the United States Gross National Product (GNP) grew at an annual rate of 3.4 per cent while energy consumption grew at an annual rate of 5.6 per cent. During the following forty years, energy consumption growth fell below Gross National Product growth, annual energy growth averaging 2.1 per cent and GNP growth 3.2 per cent. This relatively slower growth of energy consumption has been attributed to the rapid rise in electrification, which increased the efficiency of factory operations formerly dependent on the limitations of plant layout

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[1]Joel Darmstadter, "Energy Consumption: Trends and Patterns," in Energy, Economic Growth, and the Environment, ed. by Sam H. Schurr (Baltimore: Johns Hopkins University Press, 1972), p. 168.

imposed by the coal-buring factory steam engine.[2] Energy consumption per dollar of GNP continued to decrease from 1960 to 1965, at which time a sharp reversal occurred. Between 1965 and 1970, energy consumption increased by 5 per cent annually while GNP rose by 3.2 per cent. Much of this reversal has been attributed to the fact that the historical increase in the efficiency of electric generation ceased at that time.[3] Subsequent increases in electric usage, therefore, brought increases in electric conversion losses. The stepped-up use of energy for transportation also contributed to the reversal of the trend. The remaining influence on trend reversal has been attributed to many minor causes.

In 1970, the United States consumption of energy resources, in terms of heat contained, amounted to 69 quadrillion British thermal units. This was composed of approximately 20 per cent coal (used mainly in the generation of electricity), 33 per cent natural gas, 43 per cent petroleum, and 4 per cent hydro and nuclear energy.[4]

Changes in Consumption of Primary Energy Sources

Coal was the dominant energy source in household, industry, transport, and commerce markets well into the 1920's. Petroleum, spurred by the growth of automobile transport, subsequently began to challenge coal's position.

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[2] _Ibid._, p. 169.

[3] _Ibid._, p. 171.

[4] Darmstadter, "Energy Consumption: Trends and Patterns," p. 159.

Oil and gas, while not immediately displaying direct cost advantages over coal when they became available, offered numerous attributes of convenience, transportability, and combustibility that frequently tended to compensate for a higher price.[5] Coal maintained a greater than 50 per cent share of energy consumption until after World War II because of its grip on electric generation, space heating, and steam locomotive uses.

Since 1950, natural gas has made rapid gains at the expense of coal, with an average growth rate of over 7 per cent. Natural gas growth has occurred mainly in the area of household and commercial consumption, accounting for over 50 per cent of household and commercial consumption in 1970. This energy is used mainly for comfort heating.[6] By 1970, the use of coal had virtually disappeared from the household and commercial sector except for its indirect impact through the generation of electricity.

The Role of Electricity in Energy Consumption Trends

Sales and Revenue Shares by Type of Customer

In Table 5 it is indicated that total United States kilowatt-hour sales of electricity to all classes of customers have more than doubled since 1960. The share of total sales to the residential class has remained relatively stable. The commercial sector of the economy, which is reflected to a large extent by users in the small light and power category of Table 5, has assumed

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[5] Ibid., p. 189.

[6] Ibid., p. 167.

a somewhat larger share at the relative expense of the industrial sector, which normally comprises the bulk of the large light and power category.[7] Growth in total electric sales has been due to increased consumption by all classes of users.

TABLE 5

ELECTRIC SALES BY YEAR AND CLASS OF SERVICE IN THE UNITED STATES

Year	Total Sales to Ultimate Customer in kWh	Per Cent of Energy Sales by Class: Residential	Commercial & Industrial: Small Light & Power	Commercial & Industrial: Large Light & Power	Other
1970	1,391,359	32.2	22.5	41.2	4.1
1969	1,307,178	31.2	21.9	42.6	4.3
1965	953,414	29.5	21.2	45.4	3.9
1960	683,199	28.7	16.8	50.5	4.0

Source: Edison Electric Institute, Statistical Yearbook, 1970, (New York: Edison Electric Institute, 1971), pp. 43-44.

The production of electricity has assumed a steadily increasing share of total energy resources, rising from 8 per cent in 1920 to 25 per cent in 1970. It has achieved an annual average growth rate of 7 per cent, a pace greater than total energy consumption, Gross National Product, or population growth. It has

[7]Darmstadter, "Energy Consumption: Trends and Patterns," p. 172.

been estimated that one-fifth of total electricity growth is due to population increases and 80 per cent to growing levels of per capita consumption.[8]

The general trend of unit cost by customer class since 1955 is shown in Table 6.

TABLE 6

AVERAGE REVENUES PER KILOWATT-HOUR SOLD: TOTAL UNITED STATES ELECTRIC UTILITY INDUSTRY

Year	Residential	Commercial & Industrial: Small Light & Power	Commercial & Industrial: Large Light & Power	Street & Highway Lighting	Other Public Authorities	Railroad & Railway
1970	2.10¢	2.01¢	0.95¢	3.38¢	1.20¢	1.49¢
1969	2.09	1.99	0.91	3.25	1.16	1.39
1968	2.12	2.00	0.90	3.18	1.18	1.35
1965	2.25	2.13	0.90	2.99	1.34	1.31
1960	2.47	2.46	0.97	3.18	1.49	1.31
1955	2.65	2.50	0.94	3.05	1.42	1.15

Source: Edison Electric Institute, Statistical Yearbook, 1970, p. 53.

Unit costs for the three major categories experienced a decreasing trend before 1970. In the late 1960's, utilities began asking for general rate

[8] Ibid., p. 160.

increases, which is reflected in increased 1970 average revenues. As of 1973, this trend is expected to continue.

Commercial and Industrial Consumption of Electricity

Data published by individual utilities and the Edison Electric Institute are not separated by commercial-industrial categories but by size of customer, as mentioned above. In the small light and power (commercial) category, electricity is used principally for lighting and air conditioning.[9] Lighting levels in stores, offices, and restaurants increased gradually from 1920 to 1970. Air conditioning has become a necessity in order to remove the heat of the light fixtures from many buildings. Less use of air conditioning would be possible if some lights could be turned off during hot periods, but it would be unrealistic to expect commercial establishments to abandon air conditioning and high lighting levels altogether. Retail stores would lose customers without air conditioning. Without air conditioning, office buildings would lose tenants. Data processing equipment requires close temperature and humidity tolerances to prevent malfunction.

The increased use of electricity in the industrial sector has closely paralleled the growth of technology and the economy. For most industrial firms, the cost of electricity accounts for only a small part of the total value of product. Table 7 contains ratios of cost of purchased power to value of product by three-digit Standard Industrial Classification.

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[9] Abraham Gerber, "Energy Growth and the Environment," Public Utilities Fortnightly, LXXXIX, No. 12 (June 8, 1972), 71.

TABLE 7

COST OF PURCHASED POWER AS A RATIO OF VALUE OF PRODUCT

SIC Code	Industry	Purchased Power Cost Per kWh	kWh Per Dollar Value of Product	Per Cent Cost of Purchased Power to Value of Shipment
20	Food and kindred products	1.30¢	0.319	0.41
21	Tobacco manufactures	1.07	0.173	0.19
22	Textile mill products	0.88	1.050	0.93
23	Apparel, other textile products	1.86	0.169	0.32
24	Lumber and wood products	1.22	0.712	0.87
25	Furniture and fixtures	1.50	0.325	0.49
26	Paper and allied products	0.81	2.340	1.90
27	Printing and publishing	1.51	0.268	0.41
28	Chemicals and allied products	0.61	2.771	1.69
29	Petroleum and coal products	0.74	1.011	0.75
30	Rubber and plastics products	1.15	0.844	0.97
31	Leather and leather products	1.60	0.258	0.41
32	Stone, clay, and glass products	1.02	1.441	1.47
33	Primary metal products	0.63	2.822	1.79
34	Fabricated metal products	1.41	0.428	0.60
35	Machinery, except electrical	1.30	0.356	0.46
36	Electrical equipment and supplies	1.05	0.443	0.47
37	Transportation equipment	1.01	0.344	0.35
38	Instruments and related products	1.37	0.311	0.43
39	Miscellaneous manufacturing industries			
19	Ordnance and accessories	1.17	0.374	0.44

Source: Edison Electric Institute, "Per Cent Costs of Purchased Power to Value of Product, Purchased Power Cost Per Kilowatt-Hour, and Purchased Power Kilowatt-Hours Per Dollar of Product from 1967 Census of Manufactures," October, 1971. (Mimeographed.)

Electricity used in industrial plants has a fixed and a variable component.[10] Electricity used for lighting and space heating does not vary appreciably with plant output. Electric power used to run machines, operate electro-chemical processes, or processes requiring heating does vary with output. Lower cost power substitutes for electricity in production processes are often either unavailable or involve very expensive changes in capital equipment.[11] Self generation is a possibility and will be discussed in a subsequent section.

Fisher and Kaysen believe that the continued growth of industrial electric consumption at rates higher than the growth of GNP will depend heavily on continuing innovation.[12] A study of industrial electric consumption in England has suggested that:

> Technological change may be such as to lead to innovations which are based on the use of electricity and which induce substitution against other fuels and labor. This need not be accompanied by favorable price movements, since it is clearly possible for significant increases in efficiency to outweigh neutral or adverse relative price changes.[13]

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[10] Franklin M. Fisher and Carl Kaysen, A Study in Econometrics: The Demand for Electricity in the United States (Amsterdam: North Holland Publishing Company, 1962), p. 120.

[11] Ibid., p. 120.

[12] Ibid., p. 9.

[13] R. E. Baxter and R. Rees, "Analysis of the Industrial Demand for Electricity," The Economic Journal, LXXVIII, No. 310 (June, 1968), 279.

Residential Consumption of Electricity

As evidenced by Table 5, total residential kWh consumption has been doubling every ten years. The study by Fisher and Kaysen revealed that residential consumption of electricity is affected by the stock of electricity-using appliances in the home. Table 8 contains the saturation levels of major residential appliançes in the United States in 1960, 1965, and 1970.

The incidence of such large kilowatt-hour using appliances as air conditioning, clothes dryers, and dishwashers has increased markedly. Data from the 1970 Census of Housing, Metropolitan Housing Characteristics, representing over 93 per cent of all housing units, indicate that home ownership appears to be a factor in the ownership of clothes dryers and food freezers but does not appear to be a factor in air conditioning ownership. Apartments may be too small to contain individual clothes dryers and freezers. Clothes could still be dried in an apartment laundry room and lockers rented in cold storage buildings by apartment dwellers, however. The incidence of air conditioning in rental units indicates that apartment dwellers consider them as much a necessity as do home owners. The same census data indicate that ownership of all three of the above appliances increases with income. The saturation level of air conditioners can therefore be expected to increase as the discretionary income of consumers increases. The saturation levels of major appliances other than air conditioning appears to be more dependent on the number and ratio of single family homes built.

A study of consumer expenditures reported that average United States families spent less than 2 per cent of family income after taxes on electricity

TABLE 8

SATURATION LEVELS OF MAJOR RESIDENTIAL APPLIANCES IN THE UNITED STATES

Product	Per Cent of Wired Homes with Selected Appliance		
	1970	1965	1960
Air conditioners, room	36.7	20.2	12.8
Bed coverings	47.5	32.4	21.3
Blenders	31.7	11.0	7.5
Coffeemakers	86.4	68.5	53.4
Dishwashers	23.7	11.8	6.3
Disposers, food waste	22.9	13.5	9.5
Dryers, clothes	E 29.4 G 12.4 T 41.8	T 24.2	E 11.9 G 5.2 T 17.1
Freezers, home	29.6	26.7	22.1
Frypans	55.2	49.0	40.7
Hotplates and buffet ranges	24.1	22.5	23.9
Irons:			
Total	99.5	98.3	88.6
Steam and steam/spray	87.1	73.9	55.7
Mixers	81.7	70.4	53.4
Radios	99.7	97.9	96.1
Ranges:			
Free-standing	38.3	31.9	30.3
Built-in	14.4	9.5	5.3
Refrigerators	99.8	99.3	98.0
Television:			
Black and white	98.7	94.1	89.9
Color	38.2	5.1	--
Toasters	91.0	81.1	70.4
Vacuum cleaners	90.7	81.2	72.5
Washers, clothes	91.9	86.9	83.1
Water heaters	E 25.4 G 55.0	E 23.2	E 20.4 G 47.6

Note: E--electric; G--gas; T--total.

Source: Billboard Publications, Inc.; Merchandising Week, annual statistical issues; 1970 Census of Housing, p. 1-254; and 1960 Census of Housing, p. 1-28.

in 1950.[14] In spite of the increasing use of electricity by residential consumers, rising incomes and decreasing unit costs of electricity have maintained electricity expenditures near that same percentage of after-tax income every year since.[15]

As mentioned previously, the extent of the saturation of major appliances increased during the 1960's. Little data are presently available on the extent of saturation of minor appliances. This omission is relatively unimportant as the annual kWh consumption of such minor appliances as electric tooth brushes, hair dryers, and floor polishers, among others, is very small in relation to the major appliances.

The way in which the 195 billion kWh of residential electricity purchases in 1960 were apportioned among different household uses appears in Table 9.

Eight identifiable sources of demand for electricity in the home accounted for 90 per cent of residential consumption in 1960. Minor "frivolous" household gadgets, therefore, did not contribute greatly to consumption of electricity in 1960, as the "all other" category also included clothes washers, radio-phonographs, irons, toasters, and grills.

In order to account for the over 200 billion kWh growth since 1960, Darmstadter made a number of calculations based on 1969 appliance saturations.

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[14] U.S., Department of Labor, Bureau of Labor Statistics, Study of Consumer Expenditures, Incomes and Savings, Vol. XIII (Philadelphia: University of Pennsylvania Wharton School of Finance and Commerce, 1957), pp. 10-12.

[15] H. S. Houthakker and Lester D. Taylor, Consumer Demand in the United States, 1929-1970, Analyses and Projections (Cambridge, Mass.: Harvard University Press, 1966), pp. 158-64.

TABLE 9

1960 SHARE OF UNITED STATES RESIDENTIAL ELECTRIC CONSUMPTION BY SPECIFIC USE

Type of Use	Billion kWh	Per Cent of Total
Lighting	43	22
Ranges	21	11
Water heaters	45	23
Air conditioners	8	4
Space heating	12	6
Refrigerators and TV sets	28	14
Home freezers	9	5
Clothes dryers	9	5
All other	20	10
Total	195	100

Source: Hans H. Landsberg, Leonard L. Fischman, and Joseph L. Fisher, Resources in America's Future: Patterns of Requirements and Availabilities, 1960-2000 (Baltimore: Johns Hopkins University Press, 1963), Chapter 10 Appendix. As mentioned in Darmstadter, "Energy Consumption: Trends and Patterns," p. 173.

and annual kWh average usages of various appliances.[16] He calculated that roughly 32 billion kWh (16 per cent) of total incremental growth was due to air conditioning alone. Another 12 per cent of the incremental growth came from the installation of electric heat, mainly in new homes. In 1969, therefore, air conditioning and space heating occupied twice their 1960 share of residential electric power consumption.

[16]Darmstadter, "Energy Consumption: Trends and Patterns," pp. 173-75.

Competition in Energy Marketing

Because electric and natural gas utilities have acquired territorial monopolies, some people feel that no competition exists in those fields. Viewed as segments of the energy supply industry, however, utilities can be analyzed in a different light. When confronted with an energy choice situation, a prospective user may be able to choose from among several courses of action. Among these courses of action are:

(1) Product or process substitution: A choice among appliances or among industrial equipment (fork lift trucks, infra-red ovens, vapor degreasers, etc.) which could use electricity, natural gas, or other petroleum products as the energy source.

(2) Make or buy decisions: Whether to generate power or buy it from a utility.

(3) Relocation: Whether or not to locate a residence or industrial plant in an area of lower energy costs if such an area is available for location.

(4) Labor substitution: Whether to substitute hand labor for electromotive power.

(5) Establish priorities for use of resources: Only so many dollars are available to potential customers. A homeowner may have to decide whether to buy a color television or take a trip to the mountains. A corporate executive may have to decide whether to purchase another punch press, another delivery truck, or pay a higher dividend.

Energy Competition in the Industrial Sector

Just as electricity was a substitute for coal in the 1920's and 1930's, natural gas and oil are now substitutes for both coal and electricity. Oil, natural gas, and electricity compete for the opportunity to supply energy to most industrial heating processes. It is also possible to install machinery powered by engines driven by oil or gas. Self generation is a possibility, although it is less feasible than purchased energy if the plant in question contains equipment requiring close voltage tolerances or constant frequency. Most self-generation equipment depends on either natural gas or oil, both of which were subject to possible future shortages and price increases during the early 1970's.

Energy Competition in the Residential Sector

During the 1950's, the competition between natural gas and electricity centered on a few appliances, including ranges, water heaters, dryers, and refrigerators. The refrigeration competition ended when Servel, the only manufacturer of gas refrigerators, withdrew from the refrigerator business during the 1960's. Range and water heater competition still exists. Many electric utilities have remained competitive in the water heating market by introducing special rates for customers with electric water heaters.[17]

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[17] Irwin M. Stelzer and Bruce C. Netschert, "Hot War in the Energy Industry," Harvard Business Review, XLV, No. 6 (November-December, 1967), 15.

Natural gas utilities stepped up the promotion of gas air conditioning in the late 1950's but had not achieved significant success in the residential sector by 1970.

Electric utilities began aggressive nationwide competition for the residential and commercial space heating market in the late 1950's. Before that time, electric.space heating had been virtually unheard of other than in the far southern and northwestern sections of the country. The campaign to promote residential electric space heating has featured attempts to persuade prospects to upgrade the insulating capability of the home. Special competitive rates are also often available to adopters of electric heat.

Natural gas had become dominant in the space heating field by 1970, serving the space heating needs of over 55 per cent of all United States residences. Gas has seen the cooking market share lead (51 per cent to 31 per cent) which it held in 1960 eroded to a 49 per cent to 41 per cent lead in 1970, as the majority of new homes featured electric ranges. Gas water heating has been dominant, holding a 48 per cent to 20 per cent share of market lead in 1960 and a 55 per cent to 25 per cent lead over electric in 1970. There are some areas where piped natural gas is not available and in which electric water heating is dominant, but these areas are constantly shrinking. Electric clothes dryers led gas dryers 12 per cent to 5 per cent in the 1960 share of market and again 29 per cent to 12 per cent in 1970.[18]

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[18]U.S., Department of Commerce, Bureau of the Census, Eighteenth Census of the United States, 1960: Housing, I, p. 1-28; and Nineteenth Census of the United States, 1970: Housing, I, p. 1-254.

Much residential energy competition is centered on the new home market. Decisions as to the type of energy to be employed on such major uses as heating, central air conditioning, water heating, and built-in ranges are most commonly made at the time a home is constructed. Energy marketers consider the new home market important because the average life of major appliances runs from eight to twelve years, and the homeowner is unlikely to switch from one fuel to another before the appliance wears out.[19] The energy choice decision on the above appliances is often made not by the homeowner or renter but by the builder or developer in advance of the sale or rental of the residence. In this case, it is likely that the builder, within limits, is less concerned with the ultimate operating costs of the appliances than he is with the installed costs.[20] When the appliance does wear out, it is normally cheaper to replace it with one of like fuel than to spend the extra amount to wire or pipe another energy to its location. Because of the large capital investment required, the self-generation concept has not readily lent itself to the residential market.[21]

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[19]Phillips, The Economics of Regulation, p. 30.

[20]State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 15.

[21]Stelzer and Netschert, "Hot War in the Energy Industry," p. 16.

Several studies, including those of Fisher and Kaysen, Wilson, and the New York Public Service Commission,[22] have noted the possibility of varying degrees of long-range price elasticity of demand for specific uses of electricity. These possible elasticities have all been associated with the possible substitution of natural gas or oil for electric energy in the case of specific uses. These studies assumed possible future electric price increases relative to oil and natural gas. Since these studies, the forecast for the oil and natural gas industries is for possible product shortages in the mid and late 1970's. Massive price increases have been predicted for coal, oil, and natural gas by John G. McLean, Chairman and Chief Executive Officer of Continental Oil Company.[23]

Coal reserves in 1972 were estimated to be capable of satisfying energy requirements for more than 300 years at present consumption rates. This amounted to over five times the known oil and gas reserves in 1972.[24] Coal reserves indirectly reflect on the reserves of electricity because, as noted previously, electric generation represents the largest use of coal. McLean

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[22]Fisher and Kaysen, A Study in Econometrics: The Demand for Electricity in the United States; John W. Wilson, "Residential Demand for Electricity," The Quarterly Review of Economics and Business, XI, No. 1 (Spring, 1971), 8; and State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 14.

[23]John G. McLean, "Energy & America, Understanding the Problems, Looking for Answers," Minneapolis Tribune, November 29, 1972, p. 9.

[24]Ibid.

sees various forms of nuclear energy and more efficient use of solar energy as alleviating the drain on other energy resources long before coal reserves are consumed.[25] Much of the problem centers not on the total supply of the energy sources available but on their location, which countries control these sources, and the economic feasibility of their recovery. Coal, although in great supply, will be obtained more and more through strip mining or deep underground mining. Strip mining can have serious ecological effects unless a costly effort is made to closely restore the affected area to its original state.

Domestic oil production is projected to show little net change through the 1980's.[26] The United States will thus become increasingly dependent upon middle east countries, particularly Saudi Arabia and Iran, for supply as the total demand for energy grows. Oil company executives have expressed reluctance to rely on those countries for a major portion of crude oil requirements.[27]

Domestic production of natural gas has been projected to decrease about one-third between 1972 and 1987. Increased reliance on imports, liquified gas, and synthetic gas made from naptha is expected to hold natural gas sales at the 1972 level.[28] Natural gas will become especially scarce for

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[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid.

large volume industrial users. Robert Garfoot, Manager for Market Planning, Northern Natural Gas Company, has been quoted as saying:

> Gas prices have been held so low by regulations that gas has gotten into some markets it should never have entered. In the future, less gas will be available for large volume industrial users.
>
> The company has established a policy of adding additional capacity to the premium market--residential and small volume commercial and industrial users--who have a maximum gas usage of less than 200,000 cubic feet a day.
>
> To hold the annual volume relatively constant, we'll sell premium market service only in the winter months so it can't be used for inferior purposes, and we'll curtail our summer sales to low-end users by an amount equal to the growth in the premium market.[29]

The choice for large users, therefore, may again be confined to electricity and coal as industrial power sources.

Residential use of natural gas has also been threatened as of the completion of this paper. Present customers seem assured of an adequate supply within the foreseeable future, but several gas utilities have ceased taking on new customers until their pipeline suppliers can assure them of adequate increases in natural gas supply.[30]

These developments will all tend to increase the future price of energy. According to the National Petroleum Council, the United States consumer may face massive price increases of all sources of energy by 1985, amounting to increases of 80-250 per cent in the price of natural gas, 60-125 per cent increases in the price of oil, 30 per cent increases in the price of coal, and

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[29]Robert Hagen, "Warmer Weather Could Ease Region's Problem," Minneapolis Tribune, January 14, 1973, p. 17A.

[30]James H. Wright, "The Future of Electric Energy," Public Utilities Fortnightly, XC, No. 13 (December 21, 1972), 16.

a 30 per cent increase in the price of uranium.[31] Electricity would therefore seem to be in a relatively favorable price position for the foreseeable future.

An Evaluation of the Elasticity of Demand for Electricity

As previously mentioned, a major concern of this paper is to evaluate the use of inverted rate structures. The underlying assumption on which the proposal to invert electric rate structures is based is that the demand for electricity is sufficiently elastic to respond noticeably to the price charged per kilowatt-hour.

Several basic factors affect the elasticity of any product or service. These include:

(1) The cost in relation to the total family or business budget. As the relative cost rises, elasticity should also increase.

(2) The availability and price of substitutes.

(3) The degree of necessity attached to the service or product.[32]

(4) The extent to which the customer realizes how much he is paying for a product or service and whether he consciously relates these factors to other factors of choice.

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[31] Gil Bailey, "Energy Crisis Aspects Economic, Social, Political," Grand Forks Herald, March 6, 1973, p. 3.

[32] Garfield and Lovejoy, Public Utility Economics, p. 21.

(5) The length of time a price for a product or service has been in effect.[33]

The demand for electricity is a derived demand. Electric light, power, and heat are purchased because of their use in the production of other goods and services which are in demand.[34] The demand for electricity is elastic for some uses and not for others. This is a consequence of the diverse uses made of electricity, the relative sizes of differing classes of customers, the timing of their demands, and the possible availability of substitutes in some cases.[35]

Elasticity of Industrial Uses of Electricity

The cost of purchased electric power per dollar volume of product shipped, as shown in Table 7, page 32, indicated the small relative magnitude of electricity purchases by industry. Substitution, which consists of self-generation or changing fuels of individual equipment, is possible but has been called unlikely by Baxter and Rees in a study of British industrial demand for electricity. They stated, "It will not often be possible to substitute among fuels without also changing the type of plant and machinery used, so that, other things being equal, changes in relative fuel costs may have little effect on the

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[33]State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," pp. 11-12.

[34]Glaeser, Outlines of Public Utility Economics, p. 619.

[35]Garfield and Lovejoy, Public Utility Economics, p. 21.

relative costs of producing from different equipment."[36] Moreover, as mentioned previously, gas and oil may not be available to large industrial users as a substitute fuel in the future.

Motive power is a necessity in industrial plants and would tend, therefore, to make the use of energy inelastic. Many industrial and commercial consumers of electricity, by virtue of employing cost accounting, are aware of how much they are paying for electricity for various levels and types of uses. This knowledge of energy costs would tend to make industrial use of electricity more elastic in response to price than residential use since such awareness of cost does not exist among residential customers. However, studies of elasticity among industrial users of electricity by Fisher and Kaysen and Baxter and Rees found that the industrial demand for electricity was inelastic with respect to price.[37] The Fisher and Kaysen study noted that the only situations in which price elasticity possibly existed were in a few electricity-intensive industries.

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[36]Baxter and Rees, "Analysis of the Industrial Demand for Electricity," p. 294.

[37]Fisher and Kaysen, A Study in Econometrics: The Demand for Electricity in the United States, p. 137; and Baxter and Rees, "Analysis of the Industrial Demand for Electricity," p. 289.

Elasticity of Residential Demand for Electricity

Residential expenditures for electricity increased from $2,138 million in 1950 to $8,904 million in 1969.[38] As a proportion of total expenditure, however, expenditures on electricity remained fairly constant, at about 1.1 per cent of total expenditures in 1950 and hovering near 1.5 per cent during the 1960's.[39] On the subject of proportion of expenditures spent on electricity, a study of inverted rates by the New York Public Service Commission stated:

> The small proportion of expenditures which goes for the purchase of electricity dramatizes at once that only substantial rate increases (say a doubling of rates) could even begin to touch the residential customer in his total usage of power.[40]

Although fuel substitution is possible for air conditioning, water heating, cooking, and space heating, Fisher and Kaysen found that the price of electricity had no effect on the demand for residential electricity except for uses associated with cooking and water heating in areas where natural gas competition abounded.[41] The econometric study by John Wilson, referred to on page 42, found some price elasticity of demand and attributed that elasticity to the price and availability of natural gas.[42] This study also determined that

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[38] State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 12.

[39] Ibid., pp. 12-13.

[40] Ibid.

[41] Fisher and Kaysen, A Study in Econometrics: The Demand for Electricity in the United States, p. 5.

[42] Wilson, "Residential Demand for Electricity," p. 19.

uses associated with air conditioning were inelastic even in areas where natural gas was available.

The New York Public Service Commission study of inverted rates found that little impact on total energy consumption could be expected in the short run from rather costly conversions of space or water heating systems from electric to gas or vice versa as the investment in the current systems were sunk costs. The study further stated:

> The homeowner can be expected to resist making new outlays for conversion or alternate systems. Conversions of heating plants that have taken place historically reflected major factors other than price--much greater convenience in usage, maintenance, and elimination of nuisances. For the consumer to risk converting his equipment on the basis of fuel costs alone would require him to make rather confident estimates that future price relationships among fuel resources would remain as they are currently, despite the fact that he knows these have changed in the past. We certainly cannot expect him to convert his major appliances for heating and cooling every few years as fuel price relationships change. He can only be expected to replace them when these become old or broken down.[43]

Abraham Gerber, Vice President of National Economic Research Associates, Inc., also commented on possible changes to other energy sources:

> Even for those residential uses of electricity having feasible substitutes, the consumer's sensitivity to changes in rates in most instances will depend most importantly on the relationship between the initial costs of the various types of available appliances, and only secondarily on a comparison of operating costs. Usually there is no realistic choice between using and not using the appliance at all. The most obvious examples are space and water heating. An increase in the price of electricity, assuming the price of alternative fuels remains

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[43] State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," pp. 14-15.

unchanged, might well affect the choice among heating systems. However, it would not result in a decision to do without any space and water heating.[44]

Bills for electric service contain figures on total kilowatt-hour usage and the billing for a given period. No attempt is made to account for kWh usage by specific appliances or fixtures on the bill. The customer, therefore, knows only the amount of his total bill. He has no breakdown by specific uses for which there are substitutes against those which have none. Indeed, it would be virtually impossible for the utility to provide such information as the same electric receptacle into which a floor lamp, with no realistic substitute, had been plugged yesterday could today contain the plug of a room air conditioner which has a gas substitute. "Rule of Thumb" cards, usually containing the average operating cost per hour of each major appliance, have been distributed by some electric utilities. These cards are probably not in wide distribution, however, and are not very specific. The absence of information on cost of individual uses would tend to create inelasticity in the demand for residential uses of electricity.

The income elasticity of electric consumption has been studied by several economists. All have found definite signs of income elasticity of demand. Fisher and Kaysen studied both price and income elasticity during the period 1934-1957. Their findings indicated that income elasticity increased and price elasticity decreased over that period of time. They further predicted

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[44]Gerber, "Energy Growth and the Environment," p. 72.

that such a trend would continue.[45] The New York Public Service Commission study of inverted rates noted that a direct relationship between income level and appliance ownership, and therefore consumption, was usually recognized by market researchers. It further noted that the ability to incur the capital expenditure for appliances appeared to outweigh greatly the cost of energy to operate the appliance.[46] On a world-wide basis, Darmstadter found a:

> . . . generally close cross-sectional relationship between a country's per capita GNP and per capita energy consumption. Any graphic representation of such data invariably shows a close fit to the left-to-right, upward-sloping regression line and is associated with a high (nearly 0.9) and significant correlation coefficient.[47]

If, as has been predicted by McLean and Garfoot, oil and natural gas will be in increasingly short supply in the 1970's and 1980's; electricity should exhibit increasing inelasticity of demand with respect to price.[48] Fewer people will be able to switch to a substitute form of energy.

Summary

This chapter related the growth trends and changes in relative consumption of the major sources of energy from 1920 to 1972. Electricity

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[45]Fisher and Kaysen, A Study in Econometrics: The Demand for Electricity in the United States, pp. 10-60.

[46]State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," pp. 22-23.

[47]Darmstadter, "Energy Consumption: Trends and Patterns," p. 184.

[48]McLean, "Energy & America, Understanding the Problems, Looking for Answers," p. 9; and Hagen, "Warmer Weather Could Ease Region's Problem," p. 17A.

has assumed an increasing share of the total energy resources during that time. The average cost per kWh of electricity consumed decreased from before 1955 to 1970, when this trend was reversed. Consumption trends by residential, commercial, industrial, and other classes were discussed, as were some projections of specific consumption increases due to various uses and appliances. Competition in the energy supply industry was described, showing possible areas of competition and enumerating specific uses for which the members of the energy industry had historically competed. The present and possible future position of the competitors with respect to adequacy of supply was discussed.

The chapter concluded with a section which related factors found to have influenced elasticity of demand for products and services. The manner in which the price elasticity of electricity would be influenced by those factors both in the residential and industrial sector was noted.

CHAPTER IV

ATTEMPTS AT DEMAND MANIPULATION THROUGH PRICE TARIFF STRUCTURES AND CONTROLS

Examples of Tariffs Used to Influence Demand Timing

Several countries have made an attempt to influence the timing of the demand for electricity by adjusting the tariffs of their nationalized utilities. The adjusted tariffs have been used in an attempt to closely reflect the cost of the production of electricity and discourage consumption during certain times of the day and year. Although the effort to influence demand has received attention in several business and economic journals, details on the specific results achieved in these trials were not available at the time (1973) of completion of this paper. Short summaries of several of the situations involving attempts to discourage demand are presented below for illustration.

In Great Britain, a seasonal tariff was initiated in 1948. Called the "Clow Differential," it was designed to reduce a growing winter peak consumption by an addition of 0·35 d (0.7 cents) per kilowatt-hour on energy charges for two-part tariff customers during three winter months, compensated by a reduction of 0·1 d (0.2 cents) curing the remaining nine months of the year. The results of the tariff were discouraging, and it was abandoned after only one winter. It appeared that peak loads were not affected but that off-peak consumption had been adversely affected.[1]

By the middle 1960's, many electric space heaters had been substituted for older coal-burning heaters in Great Britain, thus seriously straining generating capacity at certain times on cold days. Consequently, another experiment was employed starting during the winter of 1966-67. Three separate tariffs were made available to a maximum of 840 customers each. As an incentive for adoption, customers were given a small initial payment. A description of the available rates is as follows:

(1) Subscribed Load Rate: As long as the subscribed instantaneous use was not exceeded, a certain rate was charged. A separate meter dial recorded any use in greater than subscribed quantities. A monthly service charge accompanied the situation in which the overload dial could be automatically disconnected during night hours.

(2) Seasonal Tariff: This tariff featured a high kilowatt-hour rate for the three winter months and a low rate for other months. The meter was automatically switched from a high-rate dial to a low-rate dial on a certain date. Off-peak daily switching with a service charge as above was available.

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[1]Houthakker, "Electricity Tariffs in Theory and Practice," pp. 5 and 21.

(3) Seasonal Time-of-day Tariff: This tariff contained a high kilowatt-hour rate for the peak hours on winter weekdays, a low night rate, and an intermediate rate for the remaining periods. The use was recorded on three dials controlled by a time switch.

No firm conclusions were expected before 1972.[2] None had appeared in any major British economic journal by early 1973.

In France about one-half of all electricity is generated in hydro-electric plants. Transmission distances are long, and therefore the cost of transmission is high. Water is much more plentiful during certain seasons. The French have, therefore, developed seasonal and regional tariffs based on transmission distance.[3] The most widely discussed is the "Tariff Vert" or "Green Tariff" instituted in 1956, which is available to large, high voltage, industrial and wholesale customers. Consumption during six winter months is billed at three rates based upon three daily time periods. Summer consumption is segregated into two separate time periods with differing rates. A study of French power costs using this tariff found that these costs exceed American costs for like on-peak use by only about 9 per cent.[4] The same study indicated that French

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[2]Ralph Turvey, "Peak Load Pricing," Journal of Political Economy, LXXVI, No. 1 (January-February, 1968), 111-12.

[3]Ibid., pp. 107-08.

[4]Eli W. Clemens, "Marginal Cost Pricing: A Comparison of French and American Industrial Power Rates," Land Economics, XL, No. 4 (November, 1964), 391-94.

customers with large amounts of off-peak use were billed an equivalent of only 14 per cent less than similar American users.

French residential customers are given the opportunity to choose one of three available tariffs. Tariff distinctions are based upon the magnitude of the instantaneous demand subscribed. If the selected instantaneous use is exceeded, a circuit breaker interrupts all electric service to the customer. In order to reestablish supply, the user must disconnect the offending extra appliance and reset his circuit breaker. The French have evidently had such cut-off provisions in electric rates for many years and have become acclimated to the occasional interruption.[5]

In spite of the fact that French residential electric tariffs feature rate increases designed to inhibit use at certain times, the total growth in use of electricity has closely paralleled that in the United States. From 1965 to 1967, French kilowatt-hours per capita were growing at a slightly slower rate than in the United States. From 1967 to 1969, however, the French kilowatt-hours per capita increased 16.8 per cent, while the increase was 15.8 per cent in the United States.

Scandinavian customers are also served from subscribed tariffs containing high demand rates but low energy rates, reflecting the fact that most of their electricity is hydro-generated. The demand charge assumes the function of a minimum charge. Any instantaneous use in excess of the demand subscribed is charged at a higher rate. It has been reported that Scandinavian

[5]Turvey, "Peak Load Pricing," p. 110.

customers have a higher "load factor" than do either American or other European residential consumers.[6] Load factor is a measure of the amount of off-peak use compared to total kilowatt-hour use. A light bulb energized continuously would have a 100 per cent load factor.

Several United States utilities have used summer-winter differentials in rates designed to reflect the increased cost of serving the peak demands occurring in the summer. As these differentials must be justified on the basis of cost differentials, the summer rates, although higher, are not twice the winter rates.

Non-Tariff Demand Manipulation

In the European countries previously mentioned, the demand for space heating has created the peaks.[7] A great deal of planning and promotion has gone into an effort to redesign heating appliances and educate the public to their use. Electric heaters have been developed which contain smaller heating capacity than normal American space heaters. The idea is to force the heater to operate on a nearly continuous basis. Whenever possible, appliances are designed to contain storage features. Although the above programs have received wide attention in European journals, specific data on test-case demand comparisons are not provided.

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[6] *Ibid.*, pp. 109-10.

[7] Houthakker, "Electricity Tariffs in Theory and Practice," p. 21.

A 1972 study indicated that a close relationship had existed over at least the previous ten years between useful energy consumed per capita and GNP per capita in both the United States and Western Europe.[8] This appeared to indicate that, although demand timing might have been affected slightly, total kilowatt-hour consumption had not been greatly affected by differences in tariff systems between countries.

Since the 1960's, the peak demand on virtually all United States electric utility systems has been occurring during the afternoons of very hot summer days. This peak has been attributed to the widespread use of air conditioning by all classes of customers. Air conditioning has been used to remove not only the heat absorbed into buildings from outside but also the interior heat gains from lighting, cooking, and electric machinery. This latter type of heat gain is concurrent with the power use required to remove it. It is, therefore, virtually impossible to stagger these demands without causing discomfort to the occupants of the building. Machines designed to cool the large quantities of air involved do not readily lend themselves to storage characteristics. American electric utilities began a campaign to encourage manufacturers to build efficient air conditioning equipment in the early 1970's. Consumers were urged to check the comparative input against cooling output in order to save on their electric bills.

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[8]L. G. Brookes, "More on the Output Elasticity of Energy Consumption," The Journal of Industrial Economics, XXI, No. 1 (November, 1972), 90.

An Illustration of the Effect of Ascending-Price Tariffs on Actual Electric Bills

Current national data indicating a distribution of average customers by annual consumption is unavailable.[9] A study of inverted rates by the New York Public Service Commission contained some estimated class distribution data from Consolidated Edison Company in New York City. This class distribution is used to illustrate the effect of decreasing the early steps of a tariff while increasing the price of the end step which affects only larger users on ascending-price tariffs.

For purposes of illustration, the net bill of those 15 per cent of total residential customers who use the least power is decreased approximately 25 per cent. Under the assumption that the utility should neither be penalized nor receive windfall profits, the total revenue per thousand customers will remain constant. Revenue to the utility is held constant by determining the revenue per thousand customers under the present rate structure and closely approximating the same revenue per thousand residential customers under a new rate structure. It is then possible to calculate the electric bill of an average high-use customer in the Consolidated Edison system and note the increase in his bill due to such manipulation.

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[9]State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 37.

The comparison is made in two tables. In Table 10 is indicated the present distribution of bills. The results of manipulation are shown in Table 11.

An analysis of the data contained in Tables 10 and 11 indicates that if the final step of Tariff SC 1 was arbitrarily raised to a unit cost of 9.5 cents, the total bill of the high user averaging 634 kilowatt-hours per month would approximately double from $18.76 to $37.43. It has been speculated that such an increase could possibly begin to have an effect on residential use by those customers.[10] If such a step rate increase were to be put into effect, however, it would raise $12,726.20 in the end step alone per 1,000 customers. In order that the utility involved avoid windfall profits, it would have to refund all bills paid by approximately two-thirds of its residential customers. Such a situation would appear to be unwise in view of the fact that studies have shown that customer costs are not being recovered in early steps under the present tariff systems.[11]

Summary

Several countries have instituted tariffs designed to discourage use at certain periods of the day or year. Little data on the results of such revised tariffs on peak demands has been published in major journals. Interrupting

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[10] Ibid., p. 13.

[11] Edwin Fleischmann, "The Customer Component of Utility Costs," Public Utilities Fortnightly, LXXXIX, No. 5 (March 2, 1972), 26-34; and Irwin M. Stelzer, "Marketing, Environment and Rates," Public Utilities Fortnightly, XCI, No. 3 (February 1, 1973), 29-30.

TABLE 10

ESTIMATED CLASS DISTRIBUTION OF RESIDENTIAL CUSTOMERS AND RESIDENTIAL REVENUE BY MONTHLY KILOWATT-HOURS CONSUMED
(Consolidated Edison Company, 1968)*

Tariff SC 1 (Residential)			Cumulative					
kWh Use	Rate	Revenue in Block	Revenue	kWh	Group Average Use Within Block	Cumulative Billing for Average kWh Uses	Per Cent of Total Con. Ed. Customer in Class	Dollars in Class per 1,000 Customers
First 10 or less	$1.70	$1.70	$ 1.70	10				
					45	$ 3.33	1.2	$ 39.96
Next 50 kWh	4.65¢ each	2.33	4.03	60				
					73	4.51	2.0	90.20
					88	5.05	2.4	121.20
					115	6.04	7.5	453.00
Next 60 kWh	3.65¢	2.19	6.22	120				
					142	6.86	8.8	603.68
					188	8.19	14.1	1,154.79
					234	9.53	11.2	1.067.36
Next 120 kWh	2.90¢	3.48	9.70	240				
					292	10.90	16.8	1,831.20
Next 120 kWh	2.30¢	2.76	12.46	360				
					634	18.76	34.0	6,378.40

SUB-TOTAL

TABLE 10--Continued

Tariff SC 1 (Residential)			Cumulative		Group Average Use Within Block	Cumulative Billing for Average kWh Uses	Per Cent of Total Con. Ed. Customer in Class	Dollars in Class per 1,000 Customers
kWh Use	Rate	Revenue in Block	Revenue	kWh				
Next 420 kWh	2.30¢	$9.66	$22.12	780				
							TOTAL	$11,739.79

*Class divisions provided to New York Department of Public Service by Consolidated Edison Company.

Source: State of New York, "The Inverted Rate Structure--An Appraisal, Part I--Residential Usage," p. 38a.

TABLE 11

ESTIMATED CLASS AND TOTAL DISTRIBUTION OF DOLLARS IF TARIFF SC 1 IS ALTERED AS NOTED

Altered Tariff			Cumulative		Group Average Use Within Block	Cumulative Billing for Average kWh Uses	Per Cent of Total Customers in Class	Dollars in Class per 1,000 Customers
kWh Use	Rate	Revenue in Block	Revenue	kWh				
First 10 or less	$1.00	$1.00	$1.00	10				
					45	$1.81	1.2	$ 21.72
Next 50 kWh	2.30¢ each	1.15	2.15	60				
					73	2.45	2.0	49.00
					88	2.79	2.4	66.96
					115	3.42	7.5	256.50
Next 60 kWh	2.30¢	1.38	3.53	120				
					142	4.04	8.8	355.52
					188	5.09	14.1	717.69
					234	6.15	11.2	688.80
Next 120 kWh	2.90¢	3.48	7.01	240				
					292	9.19	16.8	1,543.92
							SUB-TOTAL	$3,700.11*

TABLE 11--Continued

Altered Tariff			Cumulative		Group Average Use Within Block	Cumulative Billing for Average kWh Uses	Per Cent of Total Customers in Class	Dollars in Class per 1,000 Customers
kWh Use	Rate	Revenue in Block	Revenue	kWh				
Next 394 kWh	4.20¢		$23.56	634	634			

*Therefore, $8,039 ($11,739 - 3,700) must be recovered in the last use class. In order to recover this amount with an average use of 634 kWh as shown in Table 10, a trial and error price-per-kWh fitting indicated that a final step cost of 4.20¢ per kWh, or an increase in the final step of 82.6 per cent (4.2¢/2.3¢), the revenue in this particular class would be $8,010.40. The effect on a large user is measured by dividing his bill under the experimental rate. At a use of 634 kWh, the bill under the experimental rate would be $23.56. The large average user would experience a bill increased by 25.6 per cent.

devices such as circuit breakers have been used in some instances to prevent the subscribed maximum demand from being exceeded. Analysis of both Western European and American growth in electric consumption suggests that total growth in residential consumption has not been affected by the structures of tariffs used.

Manipulation of tariffs employing average large users of residential electricity in New York City indicated that unless the changes in individual rate steps were much more radical than those which have been proposed by the advocates of inverted rates, the monthly bill to the average large user would not increase enough to inhibit consumption of electricity.

CHAPTER V

SUMMARY AND CONCLUSIONS

This thesis has represented an attempt to evaluate the effects which would result from the inversion of electric power tariff structures. Proponents of such inversion advocate either to slow greatly or to stop the increased use of electricity by "frivolous" luxury items. They consider such use a threat to the environment.

Characteristics of Public Utility Marketing

Public utilities operate as monopolies. Regulation by governmental bodies has been accepted as a substitute for competition. Monopoly status has been allowed and encouraged because public utilities supply services indispensible to modern living and operate with greater economy and efficiency when they monopolize a market.

A public utility's rights and duties have been defined in a long series of laws and court decisions. The rights include: (1) a grant by public authority of a franchise to serve a specific area free from competition from another seller of the same service; (2) the power to charge reasonable rates; (3) a limited right of eminent domain; (4) the right to operate under reasonable rules and regulations.

The duties include: (1) supplying all reasonable demands for service by those who can pay for it; (2) providing service adequate to the needs of customers; (3) pricing such service at reasonable rates and without unjust discrimination; (4) prohibiting changes in utility service or expansion into a new market without prior finding by a regulatory agency that such is in the public interest; (5), exercising care to protect the safety of the public; (6) securing of approval from public authority before the termination of a type of service or the abandonment of a market.

Utility tariffs, or "rates" as they are known in the electric power industry, must be just and reasonable. Rate relationships are based upon both the cost and value of service.

The demand for electric service fluctuates sharply according to daily, weekly, and seasonal patterns. As electricity cannot be stored, the utility must stand ready to meet any demand placed on it. The equipment of the utility is sized to meet that demand.

The cost of providing electric service has been divided into energy costs, demand or capacity costs, customer costs, and residual costs. Electric tariffs have been designed so that the initial step attempts to recover the customer costs. Energy costs are normally recovered last. Demand and residual costs are usually recovered in the first few steps.

Several tariff forms are found in electric utility marketing, including straight line meter rates, flat rates, block meter rates, step meter rates, Hopkinson demand rates, and Wright demand rates. Individual tariffs are normally complex. Often a single utility will offer several different types of tariffs to customers depending on their location, class of use, type of equipment used, and amount of monthly use. The customer typically thinks not in terms of cents per kilowatt-hour but in terms of the dollar amount of his electric bill paid each month. The user in unaware how his electric bill breaks down by cost elements such as lighting, space conditioning, refrigeration, or cooking.

Until recently, many utilities pursued advertising campaigns based upon illustrating the inexpensive nature of their service. A recent survey by one large electric utility indicated that 62 per cent of those replying felt that the prices charged by the utility were fair.

Utility firms employ differential pricing, establishing relatively homogeneous customer classes and applying a different rate schedule to each class. Users within a given customer class must have the same rate schedule available to them. Common class groups are residential, commercial, industrial, rural or farm, street lighting, and other uses. This system of differential pricing has been justified on the basis that demand differences, service differences, and cost differences exist among groups of customers. Value differences also exist. Some uses of electric service have better substitutes than others. The unit cost of serving smaller customers is normally higher than that of serving larger users of electricity.

Rate Inversion and the Demand for Electricity

The demand for electricity is a segment of the demand for energy of all types. Growth in the demand for energy has been closely related to economic growth in general. Coal was the dominant source of energy well into the 1920's and retained a greater than 50 per cent share of energy consumption until well after World War II. Since 1950, natural gas has made rapid gains at the expense of coal, mainly in the area of household and commercial consumption. Total annual sales of electricity have been roughly doubling every ten years since the 1920's. Sales to residential customers have been increasing at the same rate as total sales over the last fifteen years. The commercial sector has assumed a slightly larger share at the relative expense of the industrial sector.

Unit prices of electricity experienced a declining trend until 1970. In the late 1960's, electric utilities began asking for general rate increases, which caused the reversal of this trend.

The increased industrial use of electricity has closely paralleled the growth of technology and of the economy. For most industrial firms the cost of electricity accounts for only a small part of the total value of the product they produce.

Residential consumption of electricity, as noted previously, has been doubling every ten years. Average United States families spend less than 2 per cent of family income after taxes on electricity. The annual kilowatt-hour consumption of minor appliances is very small in relation to that of major appliances such as ranges, air conditioners, water heaters, refrigerators, and television sets. Eight major uses of electricity in the home, including those mentioned above, accounted for 90 per cent of household consumption in 1960. Between 1960 and 1969, roughly 16 per cent of the incremental growth in residential electric consumption was due to air conditioning. Another 12 per cent of that incremental growth was due to the installation of electric heat, mainly in new homes.

Several types of competition exist in the energy industry. The most common type of competition involves the substitution of another source of energy for electricity. Self generation and relocation to an area having lower power costs are also possible in many cases. Consumers have limited amounts of money to spend. Electricity competes against many other possible uses for this money.

Residential energy competition is centered on the new home market. A number of decisions as to the type of energy to be employed in most major appliances are made at the time a house is built. The average life of a major appliance is eight to twelve years, and the homeowner is unlikely to switch from one energy source to another before the appliance wears out. The choice of energy to be used is often made not by the homeowner or renter but by the builder, who is less concerned with operating cost than with installed cost.

Several studies of the demand for electricity have noted possible long-range price elasticity due to the availability of oil and natural gas as substitute fuels for electricity. Reserve supplies of both oil and natural gas have been decreasing during the 1970's. Prices of all energy sources, especially natural gas and oil, are predicted to increase greatly. Natural gas may not be available at any price to certain users. The possibility of competitive fuel substitution for electricity has therefore decreased.

Proponents of inverted rates assume that the demand for electricity is sufficiently elastic to respond noticeably to the price charged per kilowatt-hour. Factors which affect the elasticity of any product include: (1) the product's cost in relation to the total family or business budget; (2) the availability of substitutes; (3) the degree of necessity attached to the product; (4) the extent to which the customer realizes how much he is paying for a given product or service; (5) the length of time a given price has been in effect.

Electricity has many uses, some of which have better substitutes than others. Some uses are more necessary than others. The amount spent on electricity by both residential and industrial users compared to their total budget is small. Consumers of electricity normally do not know how much is spent on electricity for each individual application, thinking instead in terms of total monthly cost of electric power per customer.

Holding various factors constant, income elasticity was found to have increased between 1934 and 1957, whereas price elasticity decreased over the same period. The ability to incur the capital expenditures for appliances and other electricity-using equipment has appeared to greatly outweigh the cost of energy to operate the appliance. Per capita energy consumption has been shown to be closely correlated with a country's per capita increase in GNP. If, as has been predicted, oil and natural gas will be in increasingly short supply during the 1970's and 1980's, the demand for electricity should become increasingly inelastic with respect to price during that period.

Demand Manipulation Through Tariffs and Controls

Several foreign countries have attempted to control the timing of peak demand for electricity through the use of tariffs. Several examples exist of tariffs being used in conjunction with interrupting devices to control demand. Little data are available on the results of those experiments. In European countries, the peaks have been caused by the increased use of space heating. Space heaters with lower wattages and storage features are being promoted in these countries. The total historical growth in kilowatt-hour usage per customer does not seem to have been greatly affected by these types of tariffs.

An analysis of the use of an inverted rate which employed the residential tariff and consumption data of customers in New York City indicated that decreasing the price of early steps and increasing the price of the end steps of the tariff would have comparatively little effect on the monthly bill of the average large user of residential electricity. The bill to the average large user would be greatly increased only if the price of the entire tariff structure was increased. If the price of the entire tariff was increased, however, the utility would receive windfall profits.

Conclusions

A basic conclusion which may be drawn from this study is that the demand for electricity is not sufficiently elastic with respect to price to respond appreciably when an inverted rate is applied. The reasons for this conclusion are:

(1) The user of electricity spends only a small portion of his available income on electricity.

(2) Demand has been found to be growing more price inelastic since 1934. Substitution of other fuels would appear to be the only possible factor which could increase elasticity. However, the energy sources which could substitute for major uses of electricity are in shorter supply than is electricity. They will, in fact, probably be unavailable to some consumers through 1980 and beyond.

(3) Because of the shortages of substitute sources of energy, their prices will probably increase faster than the price of electricity.

(4) Consumers of electricity do not think in terms of cost per kilowatt-hour, but in terms of dollars spent on electricity per month. They have little knowledge about the unit or monthly operating cost of various uses of electricity. If the total billing was artificially raised to a level much higher than that justified by the total cost of service so as to discourage consumption of electricity, the utility would achieve windfall profits. This

artificial increase would probably be challenged by consumer advocates alleging unlawful discrimination against users of large amounts of residential electricity.

(5) The total level of revenue from customers would be required to remain relatively constant after inversion in order to meet the requirement of "reasonable rate without unjust discrimination" which has become part of a body of law regarding the obligations of utilities. The upper limit of the "zone of reasonableness" allowed as a return on investment would normally not exceed the value of the service to the customer. Unless the price exceeded the value of the service to the customer, he would likely continue to pay the price asked by the utility.

Under the circumstances listed above, the inversion of electric tariffs will probably have little effect on the consumption of electricity. Both suppliers and consumers should look to other means of avoiding resource depletion and damage to the environment.

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